Retail Tobacco Outlet Density and Youth Cigarette Smoking: A Propensity-Modeling Approach

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Objectives. We examined whether retail tobacco outlet density was related to youth cigarette smoking after control for a diverse range of neighborhood characteristics.

Methods. Data were gathered from 2116 respondents (aged 11 to 23 years) residing in 178 census tracts in Chicago, Ill. Propensity score stratification methods for continuous exposures were used to adjust for potentially confounding neighborhood characteristics, thus strengthening causal inferences.

Results. Retail tobacco outlets were disproportionately located in neighborhoods characterized by social and economic disadvantage. In a model that excluded neighborhood confounders, a marginally significant effect was found. Youths in areas at the highest 75th percentile in retail tobacco outlet density were 13% more likely (odds ratio [OR] = 1.13; 95% confidence interval [CI] = 0.99, 1.28) to have smoked in the past month compared with those living at the lowest 25th percentile. However, the relation became stronger and significant (OR = 0.21; 95% CI = 1.04, 1.41) after introduction of tract-level confounders and was statistically significant in the propensity score–adjusted model (OR = 1.20; 95% CI = 1.001, 1.44). Results did not differ significantly between minors and those legally permitted to smoke.

Conclusions. Reductions in retail tobacco outlet density may reduce rates of youth smoking. (*Am J Public Health.* 2006;96:670–676. doi:10.2105/AJPH.2004.061622)

Although recent evidence has shown that cigarette use has been declining over the past decade,[1,2] the proportion of smokers remains high. From a public policy standpoint, retail access to cigarettes is often assumed to be an important determinant of smoking behavior. Reducing the number of retail outlets is a plausible strategy to reduce smoking among all age groups.[3] To curb underage smoking, limiting the number of outlets within an area might be used in tandem with better law enforcement of youth purchasing bans. The latter, although potentially important, is not completely effective, because when legal age limits are strictly enforced, minors may seek out adult smokers to procure cigarettes in local stores.[2]

In addition to providing more opportunities to purchase cigarettes, areas with a higher density of retail tobacco outlets may also encourage use by increasing levels of exposure to point-of-sale advertising in the form of prominently placed posters and banners that display information on available brands and sale prices. Because recent legislation limits event promotions and media advertisements, the retail arena is one of the few remaining channels that cigarette manufacturers can use to target both minors and those legally permitted to purchase cigarettes.[4]

Evidence on the efficacy of merchant education and better law enforcement as a means of reducing youth smoking is not encouraging. (We use the term *youth* to span the developmental periods from childhood through early adulthood.) Much of what is known comes from randomized community trials, which restrict retail access in intervention communities through the use of merchant education programs or compliance checks using underage confidants to enforce purchasing bans for minors.[5–7] Summarizing findings from these randomized community experiments, Fichtenberg and Glantz[3] conducted a meta-analysis of 9 studies published between 1985 and 2001 and found no evidence favoring the efficacy of such approaches. Although DiFranza[8] criticized the lack of comparability of interventions in the studies summarized, these results cast some doubt on the viability of using enhanced legal compliance alone to reduce youth smoking.[3,8,9]

If reducing legal access has had limited effects, one might reason that reducing the density of outlets could be a more effective strategy for curtailing youth smoking. The evidence here is also extremely limited. In an observational study, Pokorny et al.[10] reported no association between retail tobacco outlet density and adolescent cigarette use. However, their study had access to data from only 11 local communities, limiting statistical power and generalizability. Thus, additional research is needed to identify the effect of local outlet density on youth smoking.

A challenge to such a research agenda is that, unlike studies that increase merchant education and legal compliance, studies in which communities are randomly assigned to receive different levels of retail outlet density are difficult to construct. As a result, researchers must devise effective strategies for observational studies that approximate the design features of a randomized experiment. These include measuring and controlling a host of community characteristics that would otherwise be confounded with retail outlet density.

Two techniques are commonly used to reduce confounding in nonexperimental studies of causal effects: statistical control (e.g., with multiple regression) and case-control matching (i.e., selecting case and control communities that are thought to be comparable in terms of potential confounding variables). Statistical control may lead to overparameterization if the number of potential confounders is large relative to the number of study units, as is likely to be the case in community-level studies. On the other hand, case-control matching is often difficult, as it may require a large number of units to find exact matches on even a modest number of covariates.

A useful alternative strategy that does not suffer from these limitations is propensity score stratification.[11] The idea is to create

subsets of units (i.e., neighborhoods) that are very similar on the likelihood or "propensity" to receive a treatment (i.e., exposure to retail tobacco outlets) given a set of background covariates. Ideally, each subset contains a mixture of units that did and did not actually receive the treatment. Treatment effects are then estimated within each subset and averaged to obtain an overall average effect. Adjusting for the propensity score in this way provides an effective means to control for a large number of confounders without overfitting the model that predicts the outcome.[12]

We used both standard regression and propensity scoring stratification with a sample of youths living within geographically diverse neighborhood communities in Chicago. By comparing models that use different methods of statistical control to reduce the effect of community-level confounders, we were able to examine the stability of the causal influence of retail tobacco outlet density on youth smoking. In addition, we tested whether the effect of exposure varied between minors and those legally permitted to buy cigarettes to determine whether tobacco control strategies that target retail outlet density would have a differential impact between minors and those of legal age.

METHODS

Data

The sample consisted of youths enrolled in the Project on Human Development in Chicago Neighborhoods. Trained interviewers administered the surveys to respondents. The baseline assessments were collected in 1995 and 1996, and a second wave of data was collected between 1997 and 1999.

Subjects were initially selected through a 2-stage sampling design. First, Chicago's 847 census tracts were combined into 343 neighborhood clusters, which were stratified by racial and socioeconomic characteristics obtained from the 1990 US Census. Next, 80 neighborhoods were randomly selected from within these strata, and census blocks within each of the neighborhoods were enumerated and sampled. Information on household composition was then collected for every residence within each of the blocks. Households with no children or with children who did not meet the baseline age criteria were excluded.

These efforts yielded a sample of respondents living in 80 neighborhood clusters and 178 census tracts. After consent was obtained, trained interviewers were sent to the households to gather data from both the youths and their primary caregivers.

Sample and Measures

This study employed the first 2 waves of data from 2116 young people aged 11 to 23 years. Current smoking status was assessed using a dichotomous measure of any cigarette use in the past month. Approximately 14.9% had smoked cigarettes in the past month at wave 1, and 23.5% had smoked at wave 2. The other key individual-level variable in the analyses was the definition of *minor,* which was coded as an indicator variable (0=younger than 18 years, 1=18 years or older). Other subject-level variables included age, race/ethnicity, gender, and parental education (Table 1).

The key neighborhood-level exposure variable was retail tobacco outlet density. Trained raters drove at 5 mph down every street within the selected census tracts. Each side of the block was videotaped, and observer logs were coded to gather information on land use, physical conditions, and patterns of social interaction. Additional codes were created to identify any retail locations that were licensed to sell tobacco, specifically liquor stores, gas stations, convenience stores, supermarkets, and bars.

Density was computed by dividing the number of block faces with at least 1 retail outlet by the total number of observed block faces per tract. This computation yielded data on 178 census tracts, which were used as the unit of analysis for the contextual element of this study. Potential neighborhood confounders were drawn from the 1990 census (Table 2). All neighborhood-level variables were treated as continuous in the analyses but were transformed such that values of 0 and 1 corresponded to the 25th and 75th percentiles, respectively.

Analysis Plan

Three models were estimated by means of generalized estimating equations[13] using HLM

TABLE 1—Individual and Neighborhood Sample Characteristics: Chicago, Ill, 1995–1999

	Percentage	Mean
Individual (n=2116)		
Recent smoking		
Smoked in past month (wave 1)	14.9	...
Smoked in past month (wave 2)	23.5	...
Age, y		
11–17 (wave 1)	80.3	...
18–19 (wave 1)	19.7	...
12–17 (wave 2)	69.5	...
18–23 (wave 2)	30.5	...
Race/ethnicity		
White	15.6	...
Black	37.4	...
Hispanic	43.0	...
Other	4.0	...
Gender		
Men	49.4	...
Women	50.6	...
Parental education		...
Less than high school	16.8	...
Some high school	20.3	...
High-school graduate	15.7	...
Some college	34.7	...
College graduate or more	12.5	...
Neighborhood census tract (n=178)		
Retail tobacco outlet density (percentage blocks with any retail outlets)	...	7.1
Race, %		
White	...	31.2
Black	...	35.6
Hispanic	...	30.0
Poor, %	...	21.6
≥5 y in same house, %	...	54.0
Aged >25 y with associates degree or higher, %	...	19.6
Aged >16 y unemployed, %	...	14.1
Foreign born, %	...	18.9
Households, total number	...	1331.2
Families, total number	...	838.2
Families with female-headed household, %	...	32.1

Continued

TABLE 1—Continued

Income, %		
Families with income < $17 500	...	32.3
Families with income ≥ $17 500 and ≤ $60 000	...	53.6
Families with income > $60 000	...	14.0
Tract population	...	3748.6
Aged ≥ 65 y, %	...	10.4
Aged < 18 y, %	...	28.0
Persons in owner-occupied housing, %	...	43.8
Households on public assistance, %	...	17.5
Commercial land development (percentage blocks with any commercial development)	...	45.8

6.0 software.[14] We employed the generalized estimation equation framework rather than a random effects approach, because we were interested in the population-average effect of retail tobacco outlet density on youth smoking. Because 2 waves of data were collected, the estimation accounts for the nonindependence of observations caused by repeated measures within subjects and the clustering of subjects within neighborhoods. Each of the models we fit are of the form

$$(1)\ Logit\left[\Pr\left(y_{tij}=1\right)\right]=\alpha_0+\alpha_1\left(age_{tij}\right)+\alpha_2\left(age_{tij}\right)^2+\alpha_3\left(legal_{tij}\right)+X_{ij}\beta+Z_j\gamma+\delta\left(outlets_j\right)$$

Where $[\Pr(y_{tij}=1)]$ is the probability of past month's smoking (0 = no smoking, 1 = any smoking), α_o is the intercept, age_{tij} is the age of subject i in neighborhood j at time t (centered at age 16 years to assign a meaningful value to the intercept), *legal* is an indicator variable indicating whether subject i is aged 18 years or older at time t, X_{ij} is a vector of individual-level covariates (race, gender, parental education), Z_j is a vector of neighborhood-level covariates, and $outlets_j$ is tobacco outlet density in neighborhood j. The models were fit using the generalized estimating equation framework so that δ is the estimated population-average association between tobacco outlet density and the log-odds of cigarette use, conditional on the other covariates in the model.

In the first model we fit, no neighborhood covariates other than tobacco outlet density were included. This model identifies the partial association between retail tobacco outlet density and youth smoking, adjusted only for individuals' demographic characteristics. In the second model, we added a vector Z_j of neighborhood-level covariates (commercial land use, racial composition, and neighborhood poverty), with conventional covariate adjustment to control for neighborhood characteristics confounded with retail tobacco outlet density and cigarette use.

The third model is based on the strategy of propensity score stratification, which enables adjustment for a large number of neighborhood-level covariates.[11] For a binary treatment, the propensity score is the conditional probability of treatment group assignment given observed covariates. In large samples, stratification on the estimated propensity score removes all bias associated with the observed covariates. In finite samples, one must check to ensure that all observed covariates are uncorrelated with treatment group membership within strata. If balance is achieved, estimated treatment effects within strata are unbiased under the assumption that no unobserved pretreatment covariates related to the outcome also predict treatment group membership after control for the observed covariates. For interval scale treatments ("dosages"), the propensity score is the conditional expected dosage given the observed covariates, and unbiased estimation of the dose–response group effect proceeds in a fashion similar to that in the case of binary treatments under parallel assumptions.[12]

To define the propensity strata, we first predicted retail tobacco outlet density by regressing the observed retail tobacco outlet density on neighborhood covariates. Propensity strata were then created by subdividing the predicted exposure levels into 5 strata. Because

TABLE 2—Bivariate Correlations Between 1995 Retail Tobacco Outlet Density and 1990 Census Tract Characteristics

	r	*P*
Percentage White	−0.16	.027
Percentage Black[a]	−0.17	.020
Percentage Hispanic[a]	0.37	.001
Percentage poverty[a,b]	0.22	.003
Percentage ≥ 5 y in same house[a]	−0.29	.001
Percentage aged > 25 y with associates degree or higher[a,b]	−0.22	.002
Percentage aged > 16 y unemployed	0.02	.793
Percentage foreign born[a]	0.38	.001
Total number of households[a]	0.18	.013
Total number of familes[a]	0.13	.076
Percentage families with female head of household	−0.01	.893
Percentage families with income < $17 500[a,b]	0.29	.001
Percentage families with income ≥ $17 500 and ≤ 60 000	0.09	.192
Percentage families with income > $60 000[a,b]	−0.29	.001
Tract population[a]	0.04	.002
Percentage population aged ≥ 65 years[a]	−0.08	.245
Percentage population aged < 18 years[a]	0.21	.003
Percentage persons in owner-occupied housing[a,b]	−0.35	.001
Percentage households on public assistance[a,b]	0.07	.315
Commercial development[a]	0.39	.001

Note. $n_j = 178$ census tracts.
[a]Variable used in creation of propensity score variable.
[b]Squared and cubic terms also included in propensity score.

the propensity scores are estimated from a finite sample of neighborhoods, we used an iterative process to define and verify that the strata were "balanced" on covariates—that is, that there was no association between any neighborhood characteristic and retail tobacco outlet density within any stratum. Specifically, we examined balance by computing the within-stratum correlation between each exogenous covariate and retail tobacco outlet density (e.g., [Cov(Y,X)|Stratum], where Y= retail tobacco outlet density, X=covariate). When we found a significant correlation in any stratum for any X, we modified the stratification by (1) adding nonlinear and interaction terms in the model and (2) creating an additional stratum. Using these iterative methods of modification and verification, we achieved balance on all 20 covariates listed in Table 2 with 6 strata.

The model that estimates the effect of retail tobacco outlet density with the propensity strata does not include the vector X_{ij} of person-level covariates, as these covariates are accounted for by the propensity score strata, and the model includes a vector D_j of stratum indicator variables in place of the vector Z_j of neighborhood covariates:

$$(2)\ Logit\left[\Pr\left(y_{tij}=1\right)\right]=\alpha_0+\alpha_1\left(age_{tij}\right)+\alpha_2\left(age_{tij}\right)^2+\alpha_3\left(legal_{tij}\right)+D_j\gamma+\delta\left(outlets_j\right)$$

In this model, δ is the age-adjusted population-average within-stratum effect of retail tobacco outlet density.

To examine the second research question of whether retail tobacco outlet density differed between minors and those legally permitted to purchase cigarettes, we replicated these analyses by including interaction terms between the youths' legal ability to purchase cigarettes ($legal_{tij}$) and the neighborhood-level variables ($outlet_j$).

RESULTS

Distribution of Tobacco Retail Outlets

Table 2 presents the bivariate associations between the mean rates of retail tobacco outlet density and neighborhood characteristics derived from the 1990 census among the 178 census tracts. Retail outlets were less prevalent in areas with a higher proportion of African American and White residents. Conversely, retail outlets were more prevalent in neighborhoods with high concentrations of Hispanic and foreign-born residents. A negative association was observed between retail tobacco outlet density and residential mobility (e.g., residents living in the same house more than 5 years), and also with levels of poverty. Interestingly, a strong and positive association was observed between retail tobacco outlet density and the proportion of minors in the tract.

Influence of Retail Tobacco Outlets on Youth Smoking

The baseline association (Table 3, model 1) that excluded confounding neighborhood characteristics indicated that a higher retail tobacco outlet density in the census tract was associated with an increased risk of smoking (odds ratio [OR]=1.13; 95% confidence interval [CI]=0.99, 1.28), although this effect was only marginally significant (P=.062). A substantive interpretation of this finding is that a 9% decrease in retail outlet density from the 75th percentile (i.e. 11.5%) to the 25th percentile (2.8%) is associated with a 13% decrease in smoking rates. Model 2 added the neighborhood-level demographic controls; this is the model typically estimated in community studies. These results indicated that the effect of retail tobacco outlet density on smoking was both significant and positive (OR=1.21; 95% CI=1.04, 1.41; P=.011). In comparison with model 1, the odds ratio appeared to be slightly stronger, although the confidence interval was slightly larger. This change may be a result of including a set of modestly correlated covariates in the model.

The final model (model 3) estimated the effect of retail tobacco outlet density controlling for the propensity strata indicator variables, and the result indicated a significant relation (OR=1.20; 95% CI=1.001, 1.44; P=.049) to youth smoking. Because the propensity score model was based on less stringent assumptions than the regression estimates in models 1 and 2, model 3 provided a better estimate of a causal effect.

Differences by Legal Status

In separate analyses (not shown), we also examined whether the effect of retail tobacco outlet density varied between minors and those legally permitted to buy cigarettes. We estimated the cross-level interaction between time-varying legal status (e.g., minor vs legal age) and neighborhood-level characteristics. After we controlled for age, there was no additional effect of legal status on the likelihood of current cigarette use. Moreover, legal status did not significantly strengthen or weaken the relation between tobacco outlet density and current smoking in any of the 3 models.

DISCUSSION

Consistent with previous research,[15,16] we found that retail outlets were more heavily concentrated in areas of economic disadvantage, including those neighborhoods where a high proportion of residents had incomes below the poverty threshold. Interestingly, retail tobacco outlets were more highly concentrated in areas where a large proportion of residents were younger than 18 years. This result suggests that individuals may be exposed to high-risk environments during the period in which the risks of initiation of tobacco use and transitions to daily use are greatest.

Retail outlets were also found to be more prevalent in communities with a high proportion of Hispanic and foreign-born residents and a low proportion of African American residents. The negative association between African American residents and retail outlets differs from the findings of Hyland et al.,[15] who reported a significant effect in the opposite direction. Their study calculated retail tobacco outlet density as the rate per 10 km of roadway in Buffalo, NY. We repeated our analyses, calculating density as the number of outlets per block divided by the number of observed blocks for each tract. This rate was comparable to that of the study of Hyland et al., because neighborhood blocks within Chicago are of relatively fixed length. This alternative measure of outlet density was highly correlated with the measure used in our analyses (P<.001; r=0.95) and yielded regression estimates similar to those reported here. In Chicago, it appears that retail tobacco outlet density is more heavily concentrated in

TABLE 3—Estimated Effect of Retail Tobacco Outlet Density on Probability of Recent Smoking: Chicago Ill, 1995–1999

	Model 1: Crude Association		Model 2: Covariate Controls		Model 3: Propensity Strata Controls	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Neighborhood level 3[a]						
Retail tobacco outlet density	1.13 (0.99, 1.28)	.062	1.21 (1.04, 1.40)	.011	1.20 (1.001, 1.44)	.049
Commercial development	…	…	1.16 (0.93, 1.45)	.181	…	…
Percentage Black	…	…	0.50 (0.31, 0.78)	.003	…	…
Percentage Hispanic	…	…	0.83 (0.63, 1.10)	.216	…	…
Percentage poverty	…	…	0.98 (0.81, 1.17)	.833	…	…
Propensity stratum indicators						
Stratum 1 (low predicted density)	…	…	…	…	0.80 (0.44, 1.46)	.476
Stratum 2	…	…	…	…	1.09 (0.58, 2.06)	.777
Stratum 3	…	…	…	…	0.76 (0.49, 1.17)	.214
Stratum 4	…	…	…	…	0.81 (0.54, 1.20)	.301
Stratum 5	…	…	…	…	0.78 (0.52, 1.17)	.232
Stratum 6 (high predicted density)	…	…	…	…	1.00 (Ref)	…
Person level 2						
White	1.00 (Ref)	…	1.00 (Ref)	…	…	…
Black	0.43 (0.32, 0.57)	<.001	0.71 (0.47, 1.06)	.101	…	…
Hispanic	0.47 (0.34, 0.65)	<.001	0.52 (0.36, 0.76)	<.001	…	…
Other race	0.71 (0.46, 1.11)	.144	0.79 (0.49, 1.26)	.333	…	…
Women	1.00 (Ref)		1.00 (Ref)		…	…
Men	1.47 (1.20, 1.79)	<.001	1.49 (1.22, 1.82)	<.001	…	…
Less than high-school education	0.92 (0.66, 1.28)	.640	0.94 (0.67, 1.31)	.735	…	…
Some high-school education	0.97 (0.72, 1.30)	.844	0.96 (0.72, 1.30)	.835	…	…
High-school graduate	1.00 (Ref)	…	1.00 (Ref)	…	…	…
Some college	0.90 (0.69, 1.18)	.468	0.89 (0.68, 1.16)	.423	…	…
College graduate or greater	0.93 (0.67, 1.30)	.693	0.95 (0.68, 1.32)	.762	…	…
Time-varying level 1						
Aged 16 y	1.55 (1.48, 1.63)	<.001	1.56 (1.48, 1.64)	<.001	1.55 (1.47, 1.63)	<.001
(Aged 16 y)^2	0.94 (0.93, 0.95)	<.001	0.94 (0.93, 0.95)	<.001	0.94 (0.93, 0.95)	<.001
Younger than 18 y	1.00 (Ref)	…	1.00 (Ref)	…	1.00 (Ref)	…
Aged 18 y or older	0.86 (0.65, 1.14)	.309	0.86 (0.65, 1.14)	.306	0.89 (0.68, 1.17)	.427

Note. OR = odds ratio; CI = confidence interval.

[a]Neighborhood-level covariates computed as $(X_i - X_{25\text{th Percentile}}) / (X_{75\text{th Percentile}} - X_{25\text{th Percentile}})$, where 0 = 25th percentile and 1 = 75th percentile for person *i* on variable X; $n_t = 3922$ combined wave 1 and wave 2 observations; $n_i = 2116$ persons; $n_j = 178$ neighborhood census tracts.

immigrant and high-poverty communities but not in ones with a high concentration of African American residents.

We examined the influence of retail tobacco outlet density on youth smoking with the propensity score stratification approach to control for a large number of neighborhood confounders. By removing the bias attributable to these exogenous factors, we were able to improve estimates of the effect of retail outlets and report that retail tobacco outlet density was significantly associated with youth smoking. This result supports the theory that the association between youths' cigarette use and outlet density is not completely attributable to background neighborhood characteristics. However, the width of our observed 95% confidence interval (1.001, 1.49) indicates that this result may be regarded as sensitive to any failure of our assumption that all confounding characteristics were accounted for in the construction of the propensity strata.

A final contribution of this study is that previous research focused primarily on the link between retail tobacco access and underage smoking, but retail outlets also provide a source of cigarettes to those legally permitted to purchase tobacco. Past studies have suggested that retail access becomes a more important determinant of smoking behavior as youths grow older.[17,18] We found no difference in the effect of retail tobacco outlet density and rates of smoking between minors and those legally permitted to purchase cigarettes. Much of the tobacco control efforts targeting retail outlets have focused on underage purchases in an effort to prevent initiation.[5] On the basis of our findings, regulating the

density of tobacco outlets, perhaps through restrictive licensing, appears to be a plausible avenue to reduce rates of underage and young adult smoking.[19]

There are several limitations to this study. We defined cigarette use in terms of any smoking in the past month. Researchers have identified different stages of smoking and examined variables that differentially predict transitions between stages.[20–22] Accumulating evidence from genetic epidemiological studies suggests that contextual factors are stronger for the initiation of tobacco use and less influential than individual-level characteristics in promoting regular use.[23,24] Given the enormous undertaking involved in recruiting and following subjects over time in a large sample of communities, more focused investigations, perhaps using case-control methods, might consider targeting residents of high- and low-density retail outlet areas or select participants for observation who differ in their levels of cigarette use.

The choice of variables used in the construction of the propensity strata for this study may be challenged because we excluded several neighborhood and residential characteristics that have been shown to be related to youth smoking, such as tobacco advertising, neighborhood norms toward smoking, and adult smoking rates.[25,26] A key assumption of the propensity score approach is that only factors exogenous to treatment may be included in the calculation of the propensity scores. On the basis of empirical and theoretical grounds, we excluded neighborhood characteristics that could be, even in part, influenced by retail tobacco outlet density. For example, much of the advertising for tobacco products in public space occurs within the retail environment. Therefore, levels of exposure to tobacco advertising are largely conditioned by retail outlet density, and its inclusion would violate the assumption of exogeneity. In addition to these neighborhood factors, many individual-level characteristics (e.g., socioeconomic status, depression) may confer risk or resiliency given exposure to environments characterized by a high density of retail outlets. We encourage further research to examine the mediational and moderational mechanisms through which these factors operate in concert with retail outlet density to influence smoking.

We were able to identify only the level of exposure to retail outlets and had no data available regarding youths' purchasing patterns and merchants' level of compliance with underage purchasing bans. Therefore, we were unable to examine the effect of ease of access, as well as its relation to outlet density. However, an argument can be made supporting our use of the neighborhood retail density measure, given that these outlets may ultimately provide a source of tobacco for minors and adults. Although there has been a documented rise in Internet cigarette purchases among youths and adults over the past several years because of lower prices and lax age verification systems, social and retail sources remain the most common sources of tobacco reported by underage smokers.[27]

The methodological issues raised in this research with regard to eliminating confounding factors highlight the many challenges community studies face in supporting causal statements about neighborhood-level factors' influence on individual-level behavior. Overall, this study adds to the current debate regarding the use of youth access restrictions as a means to reduce cigarette use. Critics of youth access laws often cite poor merchant compliance as a reason to abandon these types of policies but also acknowledge that tobacco control efforts should employ comprehensive strategies targeting both systemic and individual levels. These include cigarette taxes,[28] mass media campaigns,[29] public smoking bans,[30] school-based prevention programs,[31] and increased insurance coverage to promote greater access to smoking cessation treatments.[32]

Although our study was limited to only a single city, it provides powerful support for the notion that control efforts should restrict the number of tobacco licenses within a given area to reduce both underage and adult smoking. Additional studies that apply the propensity modeling approach to other metropolitan and rural areas will provide valuable insight into the generalizability of these findings. ■

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S.P. Novak, S.F. Reardon, S.W. Raudenbush, and S.L. Buka contributed to the development of study hypotheses, planning of the analyses, and writing of the article. S.P. Novak analyzed the data and led the team in writing the article.

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Human Participant Protection

This work was approved by the institutional review boards at Harvard University and RTI International. All participants consented to be interviewed, and written parental consent was obtained for those respondents younger than 21 years.

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